

Note on Vapour Exposure Limits

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The COUPP experiment at SNO Lab uses two potentially hazardous volatile substances. Propylene Glycol and Iodotrifluoromethane (CF₃I). This note describes the pertinent regulations and exposure limits to these chemicals.

Regulations

The Ontario Occupational Health and Safety Act of 1990, [Regulation 833, Control of Exposure to Biological or Chemical Agents](#), sets limits on the exposure to hazardous chemicals in the workplace. Quoting Paragraph 4,

Without limiting the generality of section 3, every employer shall take the measures required by that section to limit the exposure of workers to a hazardous biological or chemical agent in accordance with the following rules:

1. If the agent is listed in the Ontario Table, exposure shall not exceed the TWA, STEL, or C set out in the Ontario Table.
2. If the agent is not listed in the Ontario Table but is listed in the ACGIH Table, exposure shall not exceed the TWA, STEL, or C set out in the ACGIH Table.
3. If the Table that applies under paragraph 1 or 2 sets out a TWA for an agent but sets out neither a STEL nor a C for that agent, *exposure shall not exceed the following excursion limits:*
 - i. Three times the TWA for any period of 30 minutes.
 - ii. Five times the TWA at any time.
4. Paragraph 3 does not apply with respect to an agent that is prescribed as a designated substance under Ontario Regulation 490/09 (Designated Substances) made under the Act. O. Reg. 491/09, s. 4.

The American Conference of Governmental Industrial Hygienists, ACGIH, defines Threshold Limit Values, TLVs, as, “guidelines to assist in the evaluation and control of potential workplace health hazards”. Regulation 833 makes the TLVs a legal limit in Ontario.

From ACGIH¹,

Definition of the TLVs®. Threshold Limit Values (TLVs) refer to airborne concentrations of chemical substances and represent conditions under which it is believed that *nearly all workers may be repeatedly exposed, day after day, over a working lifetime, without adverse health effects*. TLVs are developed to protect workers who are normal, healthy adults. [...]

¹The ACGIH documentation quoted in this section is from the [TLV® / BEI® Introduction](#) version of 02/01/2010.

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TLV Units TLVs for gases and vapors are established in terms of parts of vapor or gas per million parts of contaminated air *by volume* (ppm), but may also be expressed in mg/m^3 . [...] Where 24.45 = molar volume of air in liters at NTP conditions (25 C and 760 torr), the conversion equations for gases and vapors [$\text{ppm} \leftrightarrow \text{mg}/\text{m}^3$] are as follows:

$$\text{TLV in ppm} = \frac{(\text{TLV in mg}/\text{m}^3) (24.45)}{(\text{gram molecular weight of substance})}$$

OR

$$\text{TLV in mg}/\text{m}^3 = \frac{(\text{TLV in ppm}) (\text{gram molecular weight of substance})}{24.45}$$

These regulations outline the legal requirements for hazardous vapour exposure. ACGIH specifically notes that these limits are not meant to guide but not to replace hazard analyses. ALARA concepts should still be followed with regards to exposure to these vapours.

Propylene Glycol

Propylene Glycol is listed under Paragraph 9, the Ontario Table, of Regulation 833 as

1. a TWA of 50ppm or $155\text{mg}/\text{m}^3$ of vapour or aerosol,
2. or a TWA of $10\text{mg}/\text{m}^3$ of aerosol for assessing the visibility in a work environment where 1,2-propylene glycol aerosol is present.

As no aerosol is being formed and not STEL or C is given, by Ontario regulations a 30 minute STEL of 150ppm ($465\text{mg}/\text{m}^3$) or a Ceiling Limit of 250ppm ($775\text{mg}/\text{m}^3$) are permissible.

From the [MSDS](#), at 25°C, the vapour pressure of propylene glycol is 0.129mmHg and it has a molecular mass of 76.09 g/mol. The vapour pressure of glycol can be used as an upper limit on the partial pressure of glycol vapours, and the occupational exposure to glycol. The partial pressure converts to 1.70×10^{-4} atm, 170ppm, or $529\text{mg}/\text{m}^3$. This is slightly above the TWA exposure limit, but is well below the short term exposure limit or the Ceiling Limit. Therefore in a worst case scenario, exposure to glycol vapours does not require respirators when exposure occurs for less than 7 hours in a shift.

Time, discomfort, and availability of personnel trained in the use of respirators makes their use an unreasonable requirement for small amounts of glycol vapours. The minimization of evaporative surface, exposure time, and making workers aware of glycol vapours are all reasonable protective measures to be taken when handling glycol.

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*Document*CF₃I

CF₃I is not listed in Regulation 833, but its TWA is listed in ACGIH as 150ppm (1.20g/m³). By Regulation 833, the ACGIH TWA is to be used, and the STEL can Ceiling Limit calculated from it. Applying multiplication factors, its STEL is 450ppm (3.61g/m³), and the Ceiling Limit is 750ppm (6.01 g/m³). Above a concentration of 2%, CF₃I has been shown to affect cardiac function in canines.

CF₃I is both colourless and odorless and has a boiling point of -22.5 °C. Gas escaping from an open container of CF₃I will be significantly colder than the surrounding air, and will fall to the floor. In the absence of turbulent mixing, this layer will warm slowly, and will remain at high concentrations at ground level for days. A large release of CF₃I will be hazardous for those unaware of its release, and who breath air from near the ground.

To mitigate these hazards, as part of daily air quality monitoring at SNOlab, I recommend that air quality samples are taken near ground level to determine the presence of CF₃I before entry is allowed. If concentrations of CF₃I in excess of the TWA is found anywhere, entrance should be barred. Workers exposed to higher concentrations of CF₃I will need to don respirators with organic vapour, OV, filters to enter the area.

To determine required safety precautions during a planned release, the concentration of CF₃I will be calculated not exceed limits in a volume of air rising more than 15cm off the ground. This is a height at which skin exposure of high concentrations of CF₃I is prevented by work boots, and at which turbulent mixing of CF₃I is unlikely to bring undiluted concentrations of CF₃I up to a person's respiratory tract. If a semicircular work area with 4m radius is cordoned off, a volume of 3.77m³ may be filled to the Ceiling Limit with an instantaneous release of CF₃I before an unacceptable hazard exists for workers outside of the cordoned area. 22.7g of CF₃I would fill this volume to the Ceiling Limit, or 2.8L of CF₃I at STP.

A full accidental release of 6kg of CF₃I would contaminate 1000m³ of air at the Ceiling Limit. This volume would fill Drift J 3.1 times over. While a full accidental release is extremely unlikely, a mitigation procedure will have to be produced.